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Date:	January 7, 2016	**XCG File No.: 03-2149-08-02**
To:	City of St. Thomas	
From:	XCG Consultants Ltd.	
Re:	Summary of St. Thomas WPCP Biosolids Options Evaluation	

1. EXECUTIVE SUMMARY

The St. Thomas Water Pollution Control Plant (WPCP) provides sewage treatment services to residential, commercial, industrial, and institutional users in the City of St. Thomas (City). The St. Thomas WPCP is a conventional activated sludge plant with a rated average daily flow capacity of 27.3 MLD. Significant portions of solids treatment train have reached the end of their useful life. As such, the City is exploring possible solutions to handle future sludge flows from the treatment plant. The City has developed a short-list of two potential treatment options:

1. Anaerobic digestion, and implementation of an energy recovery process (i.e. Combined Heat and Power); and,
2. Lystek™.

To evaluate the short-listed options, an evaluation criteria was developed and reviewed with the City. The evaluation was sorted by four main categories: Environment & Community, Social, Technical, and Economics. On November 23, the City engaged in a workshop to conduct a thorough evaluation of the short-listed treatment options to identify a preferred alternative for the plant.

Both short-listed alternative treatment options could be successfully implemented for the treatment of future biosolids at the St. Thomas WPCP. The anaerobic digestion option scored higher (i.e. 10 to 15%) on the Environmental & Community and Technical categories, the Lystek™ option scored slightly better (i.e. less than 10 %) on the Social category. Overall, the two options were close (i.e. less than 10 %) on these three categories. However, on the Economic category, the Lystek™ option was significantly better for this site. Therefore, based on results of the evaluation workshop, the recommended option for the future treatment of biosolids at the St. Thomas WPCP is the onsite Lystek™ treatment process.

2. INTRODUCTION

2.1 Background

The St. Thomas WPCP provides sewage treatment services to residential, commercial, industrial, and institutional users in the City of St. Thomas (City). The St. Thomas WPCP is a conventional activated sludge plant with a rated average daily flow capacity of 27.3 MLD. Current flows to the plant are approximately 18.1 MLD, representing 66% of the rated average daily plant capacity. The facility provides full secondary treatment of wastewater through pre-treatment (fine screens and aerated grit tanks), primary clarification, conventional activated sludge, and secondary clarifiers. Phosphorus removal is enhanced through alum addition, and ultraviolet disinfection is provided prior to discharge into Kettle Creek.

Waste activated sludge (WAS) from the secondary treatment processes is co-thickened in the primary clarifiers. Sludge consisting of both WAS and primary sludge has historically been digested onsite in anaerobic digesters, dewatered with centrifuges, and landfilled at the Green Lane Landfill.

Significant portions of existing infrastructure in the solids treatment train have reached the end of their useful life. As such, the City is exploring possible solutions to handle future sludge flows from the treatment plant. Previous investigations have evaluated expansion of the anaerobic digestion process (Steele et al., 2015), and implementation of alternative sludge treatment technologies (XCG, 2015). From these documents, the City has developed a short-list of two potential treatment options:

1. Anaerobic digestion, and implementation of an energy recovery process (i.e. Combined Heat and Power); and,
2. Lystek™.

To evaluate the short-listed options, an evaluation criteria was developed and reviewed with the City. The evaluation was sorted by four main categories: Environment & Community, Social, Technical, and Economics. On November 23, the City engaged in a workshop to conduct a thorough evaluation of the short-listed treatment options to identify a preferred alternative for the plant.

2.2 Objectives

The overall objectives of this memorandum are to:

- Summarize the criteria and scoring used to evaluate the short-listed options;
- Summarize results from the biosolids option evaluation workshop, conducted on November 23, 2015; and,
- Present the recommended treatment option for future sludge flows.

3. Overview of Short-Listed Treatment Options

3.1 Anaerobic Digestion

The St. Thomas WPCP currently uses anaerobic digestion to stabilize sludge flows. Specifically, co-thickened waste sludge from the primary clarifiers is sent to the anaerobic digesters for stabilization through reduction of volatile solids. Digested biosolids are dewatered, stored onsite, and landfilled.

Previous investigations have identified the preferred alternative for implementation of anaerobic digestion to treat future sludge flows (Steel et al., 2015). Briefly, this would be accomplished through the construction of two new primary digesters, and one new sludge holding tank. Previous investigations also defined two potential energy recovery options when considering future anaerobic digestion facilities: Combined Heat and Power (CHP) facilities, and the creation of an alternative vehicle fuel from digester gases (Steele et al., 2015). Both energy recovery options were found to provide a net benefit over a 20-year operating period. In order to develop a conservative evaluation basis, the recovery option most commonly used in Ontario, that being CHP, was considered for the analyses conducted in this report. Future dewatered biosolids would be landfilled.

3.2 Lystek™

The Lystek™ process was developed in Ontario, and has several full scale applications at wastewater treatment plants in Ontario, including at Guelph, Elora and St. Mary's. Dewatered solids are mixed with steam and potassium hydroxide in a high-shear reactor. The process is easily scalable, is carried out in a sealed reactor, and results in a pathogen-free material with a high viscosity and solids concentration (about 15%). Product biosolids can be pumped, but transfer pumps must be selected carefully to reflect the high viscosity of the processed sludge. The process operates best with feed solids between 15% and 20% total solids. Current centrifuge operations at the St. Thomas WPCP would be on the high end of this range. As such, the optimization of centrifuges operation may be required to produce an ideal cake concentration, and it is expected that this would result in a polymer addition savings.

At the St. Thomas WPCP, co-thickened waste sludge from the primary clarifiers would be dewatered in the existing centrifuges, and further processed in an onsite Lystek™ reactor. Processed sludge would be stored onsite, and land-applied to local fields. Sodium and potassium hydroxide would be the primary chemicals used in the Lystek™ process. Additional details regarding implementation of the Lystek™ process are included in a previous report (XCG, 2015).

3.3 Summary of Conceptual Costs

Selection of the preferred biosolids treatment technology included consideration of the capital and operating costs of each short-listed option. These costs have been previously presented over a 20 year life-cycle (XCG, 2015). This report evaluated the conceptual costs of each short-listed option over an expanded 60 year life-cycle to account for the impact of equipment replacement costs. Expected life-cycles for specific pieces of equipment were developed from literature sources (ASCE, 2011). The purpose of this section is to present a high level review of the conceptual level costs for each option. Comparison between these costs is carried out in Section 4.2.

Conceptual level life cycle cost analyses were based on an inflation rate of 3 percent and an interest rate of 6 percent. Capital cost estimates were based on a conceptual level of design and are generally considered to be accurate to -25% to +40%. Actual costs will depend on site specific factors such as soil and groundwater conditions, the engineering design applied, construction conditions at the time of tendering, and the extent of additional upgrades to the works that may be included in the final design. The costs presented include all equipment and appurtenances, replacement, and energy consumption. Capital costs include a 15 percent allowance for general contractor overhead, a 30 percent allowance for contingency, and a 12 percent allowance for engineering and approvals. Cost estimations have excluded operations and maintenance (O&M) costs of all treatment processes used for both short-listed options (e.g. dewatering, etc.) and labour, which was assumed to be similar for each option.

Where possible, cost estimations were taken from previous investigations of biosolids handling at the St. Thomas WPCP, were obtained directly from process vendors, or were estimated from past experience. Additional details regarding the development of these cost estimations is provided in a previous reports (XCG, 2015, Steele et al., 2015). A summary of the estimated costs is given in Table 3.1. It should be noted that replacement of equipment over the 60 year life-cycle period has been included in the capital cost estimate.

Table 3.1 Summary of 60 Year Life-Cycle Cost Analysis

	Biosolids Treatment Option	
	Onsite Lystek™ Process	**Anaerobic Digestion (2)**
Capital Cost (1)	$15,424,000	$27,125,000
Net Present Value O&M	$5,630,000	$9,462,000
Total Net Present Value	$21,054,000	$36,586,000

Notes:
1. Estimated capital costs include the present value of equipment replacement over a 60 year life-cycle.
2. Includes the estimated capital costs and O&M savings from CHP energy recovery.

4. PRELIMINARY EVALUATION OF DESIGN OPTIONS

4.1 Evaluation Methodology

Short-listed treatment options were evaluated on four basic categories; Environment & Community, Social, Technical, and Economic. Each category was evaluated on several criteria, which are detailed in Table 4.1. Each criteria was ranked on a scale from one to ten, where:

- 1 – 2: Option is poor relative to other methods in meeting the criterion;
- 3 – 4: Option is fair, but not as good as other methods in meeting the criterion;
- 5 – 6: Option is average or the same as the other methods in meeting the criterion;
- 7 – 8: Option is good or better than other methods in meeting the criterion; and,
- 9 – 10: Option is excellent or superior relative to other methods in meeting the criterion.

It is important to note the City's mission and vision statements were also referenced throughout the evaluation process. Each statement is replicated below.

City of St. Thomas Mission Statement:

"To create an exceptional City by delivering financially responsible and sustainable municipal services and support for our residents, businesses and visitors."

City of St. Thomas Vision Statement:

"To be resilient and progressive community fostering inspiring opportunities for all"

Table 4.1 Summary of Evaluation Criteria

Criteria	Description
Environment and Community	
Wildlife and Fisheries	This criterion evaluates the routine and potential negative impact on wildlife and fish resulting from the option.
Vegetation	This criterion evaluates the impacts on vegetation, soil, and shoreline of the option.
Natural Heritage	This criterion evaluates the option in terms of real and net resources prevention resulting from the operation of the option (i.e. recycling vs disposal, carbon footprint, fuel or manufactured fertilizer alternative etc.).
Surface and Groundwater	This criterion evaluates routine and potential negative impacts on the quality and quantity of surface or subsurface water resources and aquatic systems resulting from the option.
Offsite Odours	This criterion evaluates the impact of off-site odours to the public in terms of odour characteristics, intensity, frequency and duration.
Traffic	This criterion evaluates the impact of the option in terms of impeding the normal flow of traffic and/or the number, frequency and duration of vehicles on public roads.
Offsite Noise	This criterion evaluates the impact of offsite noise of facility construction, processing, and transportation attributed to the option in terms of intensity, frequency, timing and duration.
Social	
Aesthetics	This criterion evaluates the visual impact of the option structures, processing/transportation equipment, products, by-products when in general view of the public.
Quality of Life	This criterion evaluates quality of life in vicinity of plant as a result of the option.
Community Acceptance	This criterion evaluates current public perceptions and community values. This criterion somewhat reflects a risk factor in determining the success of an option and the degree of public education and public relations effort required.
Policy Requirements	This criterion evaluates policy needs to implement the option at the site (City bylaws, Ministry of the Environment and Climate Change Environmental Compliance Approval, etc.).
Meets Vision Statement / Objectives	This criterion evaluates the options ability to meet the City's goals in terms of vision and objectives.
Technical	
Proven Track Record	This criterion evaluates the option in terms of its track record in primarily the Ontario market.
Public Health and Safety	This criterion evaluates any health and safety issues (real and preserved) for the option.
Operations Health and Safety	This criterion evaluates any impacts on health and safety for operations staff in operating the option.
Integration into Current Processes	This criterion evaluates ability to integrate the option into the current sludge handling processes at the plant, reuse of existing equipment and process flow.
Reliability and Complexity	This criterion evaluates the reliability and complexity of the equipment and processes for the option.
Availability, Capacity, and Reliability of Market or Receiver	This criterion evaluates the end-use of the option's product.

Table 4.1 Summary of Evaluation Criteria

Criteria	Description
Flexibility	This criterion evaluates the flexibility of the option in terms of expandability, and operational flexibility.
Sustainability	This criterion evaluates the option in terms of its long-term sustainability.
Economic	
Capital Cost	This criterion evaluates the capital cost of the option relative to other methods, rated based on the ratio of the lowest cost to the option cost.
Operation and Maintenance Cost	This criterion evaluates the operation and maintenance costs of the option relative to other methods, rated based on ratio of the lowest cost to the option cost.
60-Year Life Cycle Cost	This criterion evaluates the life-cycle cost over a 60 year period. This criterion includes replacement costs of items such as electrical, SCADA, mechanical and piping, and structures. Each option is rated based on ratio of the lowest life cycle cost to the option life cycle cost.

4.2 Comparison of Short-Listed Treatment Options

An evaluation of the short-listed treatment options was conducted in a workshop held on November 23, 2015. The workshop began with an overview of the current solids treatment processes, and a brief review of all treatment options which were considered. During the workshop evaluation criteria and weights were finalized, and a consensus scoring of the short-listed options was completed. The agenda for the workshop is provided in Appendix A.

During the workshop, the Economics category was evaluated last so as not to impact the scoring in other categories. For purposes of scoring in the Economics category, the ratio between the estimated costs of each short-listed option was used. Preliminary cost estimates for each short-listed option were developed prior to the workshop by XCG.

An information matrix was developed during the workshop that quantitatively evaluated each short-listed option based on the evaluation criteria. A copy of the information matrix is presented in Table 4.2.

During the workshop a number of items concerning the two short-listed options were discussed. Some items required additional investigation, and had the potential to impact scoring of the treatment option. These items were followed up after the workshop, and their results were incorporated into the evaluation summarized in Table 4.2.

The following is a summary of items which required follow-up after completion of the workshop:

Digester Biogas Utilization

Preliminary cost estimates developed prior to the workshop did not include the estimated capital costs or operational benefits resulting from the generation of biogas and its use onsite in a CHP energy recovery process. During the workshop, there was discussion regarding the equipment maintenance costs required to sustain a CHP energy recovery process.

Updated economic analysis completed after the workshop included the projected capital costs and energy recovery potential from a CHP process. Analysis provided an allowance for equipment maintenance.

Options for Sludge Storage Prior to Dewatering

For the Lystek™ treatment option, co-thickened sludge storage is required upstream of dewatering. Preliminary cost estimates developed prior to the workshop assumed existing digesters would be rehabilitated to provide adequate storage volume. Rehabilitated storage tanks would be open and mechanically mixed. Costs for rehabilitation, excluding mixers, was estimated from previous work completed on Digester No. 2. Mixing the raw sludge prior to dewatering is expected to keep the sludge fresh and since storage is short-term (i.e. 2 to 3 days) separate odour control measures are not expected to be required. Previous work included gas-sealing, which is not required for this rehabilitation. As such, the estimated cost for rehabilitation is expected to be conservative. Preliminary cost estimations assumed two rehabilitations would be required over the 60 year period.

Alternatively, a new tank could be constructed for co-thickened sludge storage. Previously completed cost estimations for expansion of the anaerobic digestion process included a new sludge storage tank with a 615 m^3 volume for a cost of $1,070,000 (including contingency and engineering).

Overall, the estimated cost for sludge storage via rehabilitation was found to be similar to the estimated cost for sludge storage in a new tank. For purposes of this preliminary evaluation, it was assumed existing digesters would be rehabilitated to provide sludge storage. The best means to provide co-thickened sludge storage can be confirmed during detailed design.

Proposed Lystek™ System Sludge Storage

Preliminary cost estimates developed prior to the workshop assumed the final biosolids storage system for the Lystek™ treatment option was a lined lagoon with a cover. The sludge liner with cover will contain any odours generated from the stabilized sludge. Such a system has been previously installed in Dundalk, Ontario and in North Battleford, Saskatchewan. Discussions with Lystek™ after the workshop have indicated the liner is robust and able to withstand contact from debris and tree limbs without sustaining significant damage. However, if the liner is damaged, it can be patched. Storage liners come with a standard 15 year warranty, which can be upgraded to a 25 year extended warranty. Lystek™ suggested the liner may have a 40 to 50 year lifespan.

Updated economic analysis assumed sludge storage in a lined and covered lagoon located onsite at the St. Thomas WPCP. Further, it was assumed the lagoon would be replaced once during the 60 year period. The best means to provide treated sludge storage can be confirmed during detailed design.

Odour Control for Existing Dewatering Building

Preliminary cost estimates developed prior to the workshop included odour control from the new Lystek™ building, but did not provide additional odour control for the existing dewatering building. However, dewatering raw sludge may lead to new or increased odours at the plant in the dewatering building. Updated economic analysis doubled the allowance for odour control to address this additional odour source.

Cost of Lystek™ Systems at Other Locations

Capital cost estimations for four other Lystek™ installation sites were compared to Lystek™ capital cost estimations for the St. Thomas WPCP. Each Lystek™ system had a different project scope, as some included dewatering and/or sludge storage. Despite the variable design basis, estimated capital costs for the St. Thomas WPCP were found to be comparable to the other systems considered, based on available cost information.

Impact of Digestion on Centration Nitrogen Concentrations

The impact of the centrate quality on the activated sludge process was discussed at the workshop. Specifically, historic plant data show significant ammonia concentrations in the centrate stream returned to the head of the plant. Ammonia is formed in an anaerobic digester as a product of the biochemical breakdown of proteins or non-protein nitrogenous compounds. Therefore, if anaerobic digesters are removed from the St. Thomas WPCP, the ammonia concentration in the centrate is expected to decrease.

Sensitivity Analysis

Lastly, a high-level sensitivity analysis of the evaluation process was undertaken to review the impact of putting more weight on non-economic categories (i.e. Environment and Community, Social, and Technical). Specifically, the weighting between economic and non-economic categories was altered from 50/50 to 30/70. It was found that decreasing the weighting on the economic category did not change the preferred solution.

Results in Table 4.2 shows that anaerobic digestion received a greater score for two categories (Environment and Community, and Technical) while Lystek™ received a greater score for the Economic category. Both short-listed options scored very similarly with respect to the Social category.

With respect to the Environment and Community category, it was noted that digested solids, which are landfilled, are less likely to have an impact on the natural environment relative to the Lystek™ produced solids, which may be widely land applied. Further, it was noted that the transport of Lystek™ solids to the application site may increase road traffic relative to the anaerobic digestion option.

Table 4.2 Summary of Short-Listed Option Scoring

Criteria	Criteria Weight	Lystek™		Anaerobic Digestion	
		Rating	Score	Rating	Score
Environment and Community					
Wildlife and Fisheries	1	5	5	7	7
Vegetation	1	5	5	7	7
Natural Heritage	1	7	7	7	7
Surface and Groundwater	1	5	5	7	7
Offsite Odours	4	7	28	7	28
Traffic	3	6	18	7	21
Offsite Noise	2	7	14	7	14
Environment and Community TOTAL			**82**		**91**
Social					
Aesthetics	2	7	14	7	14
Quality of Life	2	7	14	7	14
Community Acceptance	2	7	14	6	12
Policy Requirements	2	7	14	7	14
Meets Vision Statement / Objectives	2	7	14	7	14
Social TOTAL			**70**		**68**
Technical					
Proven Track Record	2	5	10	7	14
Public Health and Safety	2	7	14	7	14
Operations Health and Safety	2	7	14	7	14
Integration into Current Processes	2	5	10	8	16
Reliability and Complexity	3	7	21	6	18
Availability, Capacity, and Reliability of Market or Receiver	4	7	28	7	28
Flexibility	2	5	10	8	16
Sustainability	2	6	12	7	14
Technical TOTAL			**119**		**134**
Economic					
Capital Cost	1	10	10	5	5
Operation and Maintenance Cost	1	10	10	6	6
60-Year Life Cycle Cost	2	10	20	6	12
Economic TOTAL			**40**		**23**

With respect to the Technical category, it was noted that anaerobic digestion is a well-established technology with wide application in Ontario and has significant process flexibility. Further, anaerobic digestion has been previously carried out at the St. Thomas WPCP, and therefore can easily be incorporated into the existing treatment train. Although Lystek™ was developed and has several installations in Ontario, the technology is not as well established, and was not perceived to be as flexible.

Economic ratings were developed as a ratio between the estimated capital, operation, and life-cycle costs for each option. Additional details regarding development of these cost estimations is available in Section 3.3, and in previous reports (XCG, 2015; Steele et al. 2015).

Using results presented in Table 4.2, scoring for each category was given a grade based on the total available score for that category. The grade for each category was then adjusted by the category weight and summed to reach a final grade ranked out of 100%. Overall results are summarized in Table 4.3.

Table 4.3 Overall Summary of Short-Listed Option Scoring

Category	Category Weight	Lystek™		Anaerobic Digestion	
		Grade	Weighted Grade	Grade	Weighted Grade
Environment and Community	20%	63%	13%	70%	14%
Social	15%	70%	11%	68%	10%
Technical	15%	63%	9%	71%	11%
Economic	50%	100%	50%	58%	29%
Overall Result	**100%**	-	**83%**	-	**64%**

Both short-listed alternative treatment options could be successfully implemented for the treatment of future biosolids at the St. Thomas WPCP. However, based on results of the evaluation workshop presented in Table 4.3, the recommended option for the future treatment of biosolids at the St. Thomas WPCP is the onsite Lystek™ treatment process.

5. REFERENCES

Steele, P et al. (2015). *St. Thomas WPCP - Planning Digester Upgrades and Energy Recovery Options*. Presented at WEAO 2015 Technical Conference, Toronto, Ontario.

XCG Consultants Ltd. (2015). *St. Thomas Water Pollution Control Plant – Biosolids Management Options.*

American Society of Civil Engineers. (2011). *Failure to Act – The Economic Impact of Current Investment Trends in Water and Wastewater Treatment Infrastructure.*

APPENDIX A
ST. THOMAS WPCP BIOSOLIDS OPTIONS REVIEW WORKSHOP AGENDA

St. Thomas WPCP Biosolids Options Review
Evaluation of Short-Listed Options Workshop
ES Upper Boardroom City Hall
Monday November 23, 2015 – 12:30 to 4:00 pm

Item

Proposed Agenda

1. Project overview
   a. Solids handling at St Thomas WPCP
   b. Current conditions
   c. Biosolids options reviewed
   d. Purpose and objectives for workshop
   e. City project problem/opportunity and Vision Statement (Mission Statement)
2. Evaluation of Short-Listed Options (see attachment 1 draft criterion)
   a. Overview of short-listed options
   b. Criterion and Category weightings presentation/review/discussion/resolution
3. Evaluation of Short-Listed Alternatives
   a. Ranking or rating system
   b. Process to be used to rank the two options – consensus or averaging?
   c. Individual ranking (rank options on tables provided)
   d. Review and consolidation of ranking or rating results
4. Life Cycle Costing
   a. Useful life for wastewater facilities (see attachment 2 draft useful life periods)
   b. Replacement schedule for short-listed options
   c. Life-cycle costing assumptions
   d. Life-cycle costing preliminary results
5. Workshop Summary
   a. Summary of workshop results
   b. Next steps